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PHOTOMICROGRAPHY.

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The subject of the paper assigned me, as you will see by the program, is Photomicrography by the Use of Ordinary Objectives, Practically Considered. The primary object of the paper is to show what can be done with such objectives as are to be found in the outfit of a physician or amateur, and to aid, as far as possible to simplify and popularise this beautiful process. The theme being a practical consideration of the art, it precludes the idea of a scientific discussion of the subject, hence I shall, in very plain words, give you a brief description of the methods which I have found best suited for this work. I will also narrate some of my failures, trusting they will act as a warning to those who may be working along this line, in order that they may avoid similar errors. With these introductory remarks, I ask your kind attention to the subject matter of the paper.

A photomicrograph has been defined briefly and properly as a "Macroscopic photograph of a microscopic object," in contradistinction to a microphotograph, which means "a microscopic photograph of a macroscopic object." I will make these terms a little plainer by saying that a photomicrograph is a photographic enlargement of a minute object, and a microphotograph is a photographic reduction of a large object. By impressing upon your minds the fact that a photomicrograph is an enlargement and a microphotograph a reduction of the objects by photography, then these terms will not be as liable to be misused as they sometimes are. For many years I labored under the impression that in order to be successful in the production of photomicrographs, I

would have to use objectives that were constructed for that special purpose, that the chemical, optical and visual foci should be coincident. I found, in reading up on this subject, that most writers so express themselves; some of them go so far as to give directions how to get a general average of these foci. They advise to work by trial and error, thus: to expose a plate slightly nearer the object than the visual focus, then another slightly farther away, and in this way find the proper location for the sensitive plate.

Recent works on photomicrography, notably Professor Gage's book on Microscopic Methods, states that good photographs can be made by the use of the ordinary objectives. He gives some very practical advice on this subject. I made many trials as per instructions given in the text-books, but the results were a hazy, out of focus, unsatisfactory negative. I sought the advice of some of my friends whom I supposed to be masters of the art, but I got the invariable answer, "that to be successful I must use objectives specially corrected for that purpose." I failed to see *why* I should not be able to get just as good an image on the plate as I could get on the focusing screen, provided the plate and screen were exactly in the same plane. I so expressed myself and was as often told, "that when I knew more about the subject, I would understand the reason why corrected objectives were a necessity." These expressions from experts only made me more eager to succeed according to my views and judgment as an amateur photographer of many years practice. I persevered, however, making many scores of failures, when at last I made this discovery, that I was beginning at the wrong end—using high power objectives before I had learned to work with the lower powers. I reasoned thus: that high power objectives, such as 1-8, 1-10 or 1-15, gave a small field and poor light, and that they required the nicest and finest adjustments, the greatest skill, the very best optical appliances and apparatus to operate them, and the most effective light for their illumination that could be obtained. The low powers, on the other hand, gave a larger field, the result

being a small picture. It then dawned upon me that what was required for successful work was to enlarge these small pictures by the use of a long camera, that is, to work upon the principle of the photographer's enlarging process rather than by the use of high power objectives. These views I have proved by many practical demonstrations, to my own satisfaction at least, to be correct.

I shall now take up the subject of apparatus, lighting, focusing and finishing of the negative, giving the details of the work as I practice them. The apparatus consists of a long bellows camera. This may be made of several sections of light-tight pine boxes, blackened inside to eliminate all reflections from the sides, and made to slide in each other, having a focusing screen and a plate holder attachment on the end of the rear section, and an arrangement at the front end section for securing the tube of the microscope to it. This may be a slip tube, or a black bag, or any simple connection that is perfectly light-tight and capable of contraction and expansion to suit the movement of the microscope tube in focusing the object, or preferably a camera made specially for this work may be used. If large negatives are to be made, I would strongly advise doing away with the camera altogether and use a dark room to serve the purposes of the camera, the microscope and light being on the outside and the tube of the microscope fitted to a door or shutter, thus shutting out all light from entering the room save that which comes through the objective. On the inside of the dark room construct a rack for carrying a movable piece suitable for holding the focusing screen and plate holder. This would be a very cheap and complete arrangement. The operator would, of course, stand inside the camera or dark room. A microscope is not a necessity; any arrangement that will hold the slide centrally and permit of the light passing through the object will answer the purpose. I use a microscope simply because I have one and on account of its convenience in making necessary adjustments and focusing.

The operation of picture-making is as follows: The

tube of the microscope is turned down so that it lies in a horizontal position; it is then attached to a short bellows and it, in turn, to the front of the camera. The substage bar and mirror bar is swung around out of the way. A Welsbach incandescent gas burner is placed back of the stage about ten inches distant, with the bright white flame located centrally. About midway between the gas jet and the stage is placed a bull's-eye condenser with the flat side towards the object, and by placing a piece of white paper on the stage the light is centered upon it; that is, I focus the bull's-eye by moving it to or from the light so as to get the best even clear light possible. When this is done the paper is removed and the slide to be photographed is placed in its position on the stage. Some prefer a mechanical stage, but as they are expensive I could not afford this luxury, but have managed to get along without one by using Bausch & Lomb's glass stage; its movements are easy and after a little practice I find it answers all my purposes. The objective is now put in place and run down to about the working distance. The object can now be seen on some part of the ground glass screen, perhaps indistinctly; when observed it should be focused by the unaided vision and the object centered carefully on the ground glass. If the circle of light is out of the center, then the camera and the microscope are not in line. Adjust them by moving the tube end of the microscope to the right or left, up or down, as required and shown by the circle of light on the ground glass. If the circle of light is not as large as the object, then an objective of lower power must be used. With a six-inch to three-inch variable I have a considerable range of field and amplification, and with a six-foot bellows extension to my camera, I have under my control a great variation in amplification, besides being able to photograph many large objects up to five-eighths of an inch in diameter. Objects that are larger than this, I take with an ordinary photographic camera. The focusing arrangement used is an extension to the pinion shaft; it is attached to the milled head and extends beyond the camera a couple of

inches ; on the end of this extension a loose lever, having a tightening screw in its hub, is placed, the lever extending down to within half an inch of the table. To the lower end of this lever a piece of stiff wire is fastened, the wire being as long as the camera bed, and is held in place by passing through eyes screwed into the bed-piece of the camera. This focusing device was invented by Dr. Mercer, and as I have not heard of his patenting this device, it can be used, presumably, by all who wish to do so. By the use of this attachment, the utmost nicety of adjustment can be made. After focusing carefully by the unaided vision, the thumb screw is tightened in the hub of the lever, then, by moving the wire rod to or from the object, a very fine focus can be obtained. With this arrangement I can focus a one-eighth water immersion objective by exercising a little care, as the slightest movement of the wire reduces the movement of the tube about one-twentieth of the motion given to the rod. Consequently there is no occasion to use a fine adjustment at all. The focusing screen is the ordinary ground glass screen, with Mr. Walmsley's improvement thereon. This consists of cementing with balsam, cover glasses, at several points around the limits of the picture and one in the center, all on the ground side of the screen, thus showing clear glass at these points. This is a very good focusing device, in fact, the best I have tried.

It is used thus : First focus by the eye, as nearly correct as possible, on the ground glass part, then with a two-inch eye-piece, used as a focusing glass, focus sharply on the cover glasses. If an object is of uneven surface, then focus for the part that is required to be shown clearly, or take a general average of the whole object. Take, for example, the fly's tongue. This object has an uneven surface ; hence, if the focusing is done upon the hairs on the false trachea, then the spirals will not be so sharp ; if we focus on the spirals, then the hairs will be slightly out of focus ; therefore, in such cases, a general average focus must be taken to show the object as a whole. The objectives I

use for photomicrography are Bausch & Lomb's student series, from one-eighth down to six inches. These will answer every purpose of the non-professional or amateur. One of the most useful objectives that I know of is one made by them. It is a six-inch to three-inch variable; it has a very good definition, and, by turning a milled collar, any range of amplification can be obtained within range of the objective, and with this lens and a long camera a great variety of work can be done. It is particularly useful for histological specimens, as it will light the whole of an object, provided it is not over five-eighths of an inch in diameter. For subjects larger than this, I resort to the ordinary photographic method of copying and enlarging, as before stated. For example of that kind of work, I point you to the photograph of the firefly, which is exhibited for that purpose. To summarise, first adjust the light, then put on the lowest power objective that will give the amplification desired, and that will also give a circle of light extending beyond the outer edges of the object. Extend the camera until the picture is of the size wanted, focus again, then attach and use the lever focusing-device before mentioned. Focus sharp on the cover glass spots, using a two-inch eye-piece, or a focusing glass for this purpose. When this is done, put in the color screen between the bull's-eye condenser and the stage of the microscope and expose about three or four times as long as you would with the same light and conditions without the screen. The screen used is one made by Bausch & Lomb for cloud photography, and it belongs to my 8 x 10 view outfit. I have it rigged up on a stand for the purpose herein named. It is a most useful affair for all objects that have a yellow tinge in the balsam or the object. It is indispensable with me for many objects; for example, the photographs of arranged diatoms on some of the souvenir cards, also on the large photographs in the frame, where some are very transparent, others not so transparent, and some are quite dense. The use of the screen seems to have the same effect on such objects as it has upon the clouds in a

landscape view. It in a great measure evens up, as it were, the different lights in the object, that is to say, it retards the high lights, which are apt to be over-exposed, to a greater degree than it does the middle lights and the shadows. Many of the diatoms in the picture shown would not be seen at all, were it not for the effect of this bi-chromate cell. I will here relate an experience I had previous to using this screen: My friend and co-worker, Mr. Harry G. Carter, of Minneapolis, sent me a slide of the proboscis of a large blue-fly, the one pictured on some of the souvenir cards, and the one shown in the large picture exhibited. I tried to photograph this slide and made over a dozen failures. I wrote to Mr. Carter that I could photograph a slide that I owned and make a success every time, but that I utterly failed to make a single picture from his slide; that the best results I could obtain was an "out of focus, hazy" kind of a negative. He replied that my lenses were not suited for the work, and that I could not expect to succeed with the objectives I was using. I answered him that with another slide I had, of the same object, I could get a good picture every time I made an exposure, hence I could not agree with him. Soon after this I tried the color screen and made a success of it at the first trial. This convinced me I was right, that the fault was outside of the objective. To still further test this matter, I bought a one-inch "no name" objective in a "spectacle shop" in Cleveland. It cost me \$4.00 with a brass box. I bought it because it was a cheap affair and certainly could not have been specially corrected for photography. I tried this objective and made some splendid good sharp pictures with it. I have it with me, also a specimen of the work it has done. Should anyone present be curious to examine them, they can do so at the close of this session.

The sensitive plate will now be considered briefly. I find in my practice that almost any of the standard make of plates will give good results. I have used Seed's, Cramer's, Eastman's, Stanley's, Carbutt's, Hammer's and many others, and

got along very nicely with all of them ; yet I have a decided preference for Cramer's slow isochromatic plates. They are a little slow, but they are much easier to work with than the more rapid ones. With the Welsbach incandescent light and a low power objective, using Cramer's crown plates without a color screen, the exposure must be made in about a half second or the plate will be spoiled from over-exposure. Of course, much depends on the character of the object. I would strongly advise slow plates, especially for those not well up in the operations of photography.

After the exposure comes the developing. This is done in the same way, and by the same reducing agents, as is practised by the ordinary photographer. There are a number of good mixed developers made, and in the photographic journals may be found the formula for compounding them. They all have merit. I can specially recommend Mr. Walmsley's "Universal Developer" as being very suitable for this purpose. I use a compound known as "Monarch Developer ;" it is prepared and sold by W. S. Bell & Co., of 435 Wood street, Pittsburg. It is a universal developer, suitable, when diluted, for negatives, transparencies, lantern slides, bromide paper, and the like. It is a very clean, clear compound, and can be used over again repeatedly. It is composed of two reducing agents—namely, hydrochinon and para-amido-phenol. I have used it for several years and can fully recommend its use as a developer. The fixing bath that I consider best is an acid bath, with chrome alum as a hardener. This I make according to Cramer's or Carbutt's formula. It clears, fixes and hardens, and is used over again until too weak to be effective ; it is then thrown away and new bath made. After the plate has been fixed and cleared it is thoroughly washed, preferably in running water, for one hour to eliminate the last trace of the hypo left in the film by the fixing process.

The negative is now to be carefully examined. If it is found to be dense enough to print from, it is then laid on a rack to dry. If it appears thin, then intensifying must be

resorted to to bring up the density or opacity of the high lights, after which it is washed well and laid aside to dry. When dry and hard, wipe the film side with a rag dipped in alcohol ; this hardens the film and cleans it off smooth and clear. Some think that a negative when dry and hard is ready to print from, but this is a mistake. There is a great deal of "doctoring" that can be done to a photomicrograph negative that will improve the appearance of the resultant positive picture. Very often we have a negative that has very little difference in the printing qualities between the object and the balsam in which it is mounted. In such cases the removal of the background is the operation to be performed for its improvement. This is done by scraping away all the film up to and close around the object, as shown by the black background in the picture of "fetal hand" exhibited. If a clear white back is desired, then the film is painted over with "Gihon's opaque," a pigment made for the purpose. This effect is also shown in several of the pictures exhibited and in some of the souvenir cards. Sometimes pin holes are found in the film or a scratch from careless handling ; these should be painted out with either Prussian blue water color or India ink, and these spots or scratches should be made of the same opacity as the surroundings. Very often the circle of light does not extend far enough to allow the print to be trimmed as it should. In that case a mat is used. This is a piece of opaque paper with the center cut out in a circle, ellipse or any other shape to suit the outline of the object. This feature can also be noticed on some of the souvenir cards. I like to use a mat because I can make a record on the margin of it, giving the exposure, objective and plate used, with date and the like. This mat I stick on to the glass side of the negative with mucilage and it always remains there.

We now come to the printing of the positive, and after trying all kinds of papers to be procured here and some from other countries, I prefer the "Platinotype" to any, for the reasons which follow : It is the busy man's paper, because it

is easily and quickly manipulated ; it is not sticky or soft ; it does not require the use of ice and a thermometer in the bath to prevent an attack of " green sickness or yellow fever ;" also because I think it more artistic for photomicrographs than shiny, glossy paper ; and lastly, every piece will make a picture sure and without the risk of losing any. This paper is expensive, but the working of it is so easy, simple and satisfactory, that if once tried it will surely meet with favor.

The operations are as follows : Print until the picture is bronzed in the shadows. When ready to develop put it in a tray or on a pane of glass and brush the developer over it ; the picture comes out instantly ; in a few minutes it is ready to be rinsed in two or three successive baths of water acidulated with muriatic acid, then washed for twenty minutes in clear water, after which they are hung up to dry, and the job is done and you have for your trouble a thing of beauty and a joy forever. They can then be mounted in an album or on cards, as may be desired.

In conclusion I will say that I advise persons having no knowledge of photography to practise the same with a view camera before commencing to make microphotographs. The knowledge so obtained will be very helpful in the prosecution of photomicrography.

I shall be pleased to answer any questions that anyone may wish to ask me, or to describe more fully any point that I have not made clear. I will also explain by letter any point of difficulty that may be met with in practice, should such occur. Address me at Warren, O., and it will receive my best attention.